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Research Article

Can Citizen Science Increase Trust in Research? A Case Study of Delineating Polish Metropolitan Areas

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Abstract

We assess the relationship between citizens' participation in scientific research and public trust in research results within social sciences. We conduct an online citizen science quasi-experiment concerning the delineation of metropolitan areas of Poland's two major cities. It consists of two stages. In stage one, participants in one region are exposed to citizen science and directly involved in delineating the boundaries of their local metropolitan area. In stage two, we add another region in which participants are not involved in the research process. In both regions we ask the participants to evaluate the level of their trust in the presented maps of respective metropolitan areas: based on citizen science in one region and historical data regression analysis in the other region. Our contribution to the literature lies in two areas. First, we demonstrate how citizen science can be used in urban studies to delineate boundaries of urban and metropolitan areas exhibiting strong functional connections. Second, we show that the participation of local residents in the research process increases public trust in the study results compared to non-participatory 'traditional academic' research. These results confirm that citizen science programs deserve to be strongly supported by European institutions as a possible means to resolving the credibility crisis of science, research and evidence-based policies.

Keywords

Citizen Science; Social Trust; Trust in Science; Urban Studies; City Boundaries

Public trust in science, or 'the trust that society places in scientific research' (Resnik 2011: 4), has become a key expression in science policy and ethics in recent decades. This growing importance of elucidating the forms and conditions of public trust in science must be considered in the context of a steady and substantial decline in trust in governance across the world, including some European Union (EU) Member States and the EU itself, over the past decade.[1] As noted by Resnik (2011), trust in governance is indeed closely related to trust in science as our 'knowledge societies' are characterised by investment in knowledge as a commons and a public good, which crucially informs policymaking processes and political action (Hess, Ostrom and McCombs 2008; European Commission 2016, 2007). Several reports from worldwide national and supra-national institutions have insisted on the need to overcome science's current 'credibility crisis' (Carrier 2017) and promote a form of public trust towards scientists and/or scientific results (for example Ruiz Bravo 2007; National Academies of Sciences and Medicine 2015; European Commission 2010; Committee on Science, Engineering and Public Policy 2009). However, despite this consensus on the importance of public trust in science for liberal democracies, it is still a challenge to precisely define what kind of public trust in science we want to promote and to identify the social and institutional conditions which could ground it.

Trust in science is determined in a complex manner. First, it depends certainly, but still in an unclear way, on the level of understanding citizens have of scientific assertions (Miller 2004; Allum, Sturgis, Tabourazi and Brunton-Smith 2008). Second, it depends on the diverse expectations of the public respect towards scientific research, which in turn depends on individual interests and social position (Grasswick 2010). Finally, the level and nature of trust are determined by ones' general 'attitude' towards science, which is driven by subjective values, ideologies or psychological states (Rutjens, Heine, Sutton and van Harreveld 2018).

The social and institutional conditions promoting both the credibility and trustworthiness of scientists and scientific results are still strongly debated. In this context, the 'opening-up' of science is increasingly considered as a way to positively influence public trust relationship towards science (Rutjens et al. 2018; Irzik and Kurtulmus 2019; Carrier 2017). This opening-up may take the form of greater involvement of lay citizens in the process of knowledge-making and the production of expertise. Such inclusiveness in scientific research is increasingly valued by scientific institutions, as shown by numerous commissioned reports (for example Office of Science and Technology Policy 2019; European Commission 2016a, 2013) and growing financial support for *citizen science*. The general concept of *citizen science* refers to a large diversity of forms of participation for citizens who are not professional scientists (individual citizens, NGOs, groups of patients, and so on) in the production of scientific knowledge (Eitzel, Cappadonna, Santos-Lang, Duerr, et al. 2017; Cooper and Lewenstein 2016). Citizen science is expected to contribute to scientific knowledge as well as improve public understanding of science (Bonney, Phillips, Ballard and Enck 2016) and let citizens gain policy influence (Van Brussel and Huyse 2019).

As our brief review of literature shows, there seems to be a consensus on the positive impact of citizen science on public trust. However, arguments to date have been based largely on theoretical grounds rather than empirical evidence. We fill this knowledge gap by empirically assessing the relationship between citizens' participation in a scientific research process and public trust in research results in the context of social sciences - urban studies, in particular. The key research question addressed in this article is whether the participation of laypersons or citizen scientists in the research process increases the trust that the public places in the social science research results. We conducted an online citizen science quasi-experiment, concerning the delineation of metropolitan areas of Poland's two major cities. Our quasi-experiment consisted of two phases in which participants were recruited using social media. Our contribution to the literature lies in two areas. First, we demonstrate how citizen science can be used to delineate the boundaries of metropolitan areas. To the best of our knowledge, this is the first study to explicitly do

this. Although this article focuses on metropolitan areas defined as clusters of towns and villages surrounding major (core) cities and exhibiting strong functional links with the core, the same approach could be followed to delineate boundaries of other urban or regional entities in human geography. Second, we conduct a quasi-experiment aimed at determining whether the participation of local residents in the research process increases public trust in the results compared to the results of non-participatory 'traditional academic' research. Our results confirm that participation of lay citizens in citizen science projects increases their trust in subsequent results.

The remainder of this article is organised as follows. First, we briefly discuss the conceptual framework and literature on public trust in science. We then present the details of our research design and the quasi-experiment. The following two sections present our results. We finally discuss our empirical insights in the perspective of a renewal of the relations between citizens and experts in the contemporaneous context, as characterised by a growing opposition between technocratic and populist discourses.

PUBLIC TRUST IN SCIENCE: EPISTEMOLOGICAL, POLITICAL AND PSYCHOLOGICAL DETERMINANTS

Modern societies are often referred to as 'knowledge societies' as they give a central place in social innovation and design of public policy to scientific knowledge. However, basing social bargaining, policymaking and political decisions on scientific knowledge is not without problems as science-based approaches bring a considerable degree of risk and uncertainty. This is particularly true in social sciences where research designs, interpretation of results, and their implications, are extremely difficult to decouple from researchers' pre-existing values and institutional bias. Knowledge should be assisted and supplemented by an in-depth, and comprehensive analysis of what makes evidence useful and usable to policy (Cartwright and Hardie 2012). The social acceptance of scientific knowledge is one of the conditions of this utility. Yet, a central determinant of its social acceptability is the nature and level of trust that society places in scientific research, namely public trust in science. The challenge here is to build a level of public trust that would be robust, informed, and critical (Resnik 2011).

More formally, Irzik and Kurtulmus (2019) define a notion of 'warranted trust' in the following way: an individual (*M*) has a *warranted trust* in a (group of) scientists (*S*) as a provider of information (*P*) if:

> '(1) *S* believes that *P* and honestly (that is, truthfully, accurately, and wholly) communicates it to *M* either directly or indirectly, (2) *M* takes the fact that *S* believes and has communicated that *P* to be a (strong but defeasible) reason to believe that *P*, (3) *P* is the output of reliable scientific research carried out by *S*, and (4) *M* relies on *S* because she has good reasons to believe that *P* is the output of such research and that *S* has communicated *P* honestly'. (Irzik and Kurtulmus 2019: 1149-1150)

In other words, trusting *S* as the provider of *P* implies that *M* has good reasons to believe that *P* is reliable, and that *S* is honest.

The issue is thus: which first-order reasons must the public possess, in order to believe that *P* is the result of reliable research, and that *S* is honest? The difficulty here lies in the epistemic asymmetries between the scientific experts and laypersons. In general, the public is not in a position to understand or evaluate first-order reasons for deciding whether a particular piece of research is reliable. Consequently, it has been defended that the general public should use 'second-order criteria' such as the perceived hierarchy of competence, the absence of conflicts of interests or the state of scientific consensus (Anderson 2011).

The perceptions of first- and second-order reasons to trust science are influenced by various types of determinants. First, some epistemological determinants have been shown to play a role in building public (dis)-trust in science. Let us consider the distinction between publicly-funded research and research sponsored by the private sector. Public research is often considered as being more honest because of the relatively lower rate of conflicts of interests (Ziman 2003) and, effectively, is perceived as more trustworthy. (Critchley 2008; Critchley, Nicol and Otlowski 2015). This is in line with the results of the European Commission's survey which found that 58 per cent of respondents agreed with the statement that *'one can no longer trust scientists to tell the truth about controversial issues because they depend more and more on money from industry'* (European Commission 2010: 19). Another epistemological determinant is linked to the confrontation of expertise and counter-expertise in the public space, which is sometimes referred to as the 'expert dilemma' (Grunwald 2003; Carrier 2017). This is often evident in complex debates where the multi-dimensionality of a problem at stake induces disagreements within scientific communities about the way the problem should be addressed (for example the case of GMO in Biddle 2018). Any general knowledge or understanding of science is also intensively discussed as a determinant of the attitude towards science, and in particular, public trust (Miller 2004). However, it is still not clear how public understanding of science influences trust. Allum et al. (2008: 35) found only 'a small positive correlation between general attitudes towards science and general knowledge of scientific facts'. Arguments have also been made that greater science literacy and education go hand in hand with more polarised attitudes on politically controversial science topics (Drummond and Fischhoff 2017). Moreover, attitudes towards specific problems are mediated by an intricate mix of scientific literacy, political ideology, morality, and religious values. The interplay of these elements appears to be especially conspicuous in the attitudes towards climate change (Hornsey and Fielding 2017), theories of evolution (Nadelson and Hardy 2015) and vaccines (Sarathchandra, Navin, Largent and McCright 2018).

This points towards the political and psychological determinants of public trust in science. An important area of research looks at the rejection of science as 'the dismissal of well-established scientific results for reasons that are not scientifically grounded' (Lewandowsky, Gignac and Obernauer 2013: 623; Lewandowsky, Cook, and Lloyd 2018). This phenomenon is also referred to as *rejection of consensus*, indicating the extent to which people identify scientific consensus and assert beliefs that contradict their own perceptions of consensus. Pasek (2018a, 2018b) shows that, in the American context, the degree of rejection of consensus depends on religiosity and partisanship. Also in the American context, Hornsey and Fielding (2017) propose a general framework of 'attitude roots' which drive the motivation to reject science. They distinguish six political and psychological determinants: worldviews, conspiratorial ideation, vested interests, personal identity expression, social identity needs, and fears and phobias. These political and psychological determinants are highly cultural and depend on the national context.

The multiplicity of determinants of public trust in science points to the role played by the institutional features of scientific knowledge production. A growing number of authors call for the opening-up of science as a way to reinforce both the credibility and the trustworthiness of scientists' propositions (Rutjens et al. 2018; Carrier 2017). Public engagement with science is considered as one of the key mechanisms for addressing the crisis of public trust Aitken, Cunningham-Burley and Pagliari 2016). However, the forms that this public engagement should take and their influence on public trust in science remain to be elucidated. In that context, the role of citizen science is debated (Van Brussel and Huyse 2019). As noted by Eleta, Galdon Clavell, Righi and Balestrini (2019: 1), the 'potential [for citizen science] to … counteract mistrust and scepticism about scientific evidence' remains a 'promise' that is still to be fulfilled. First of all, a reliable empirical assessment of how public engagement in scientific research influences the nature and level of trust the public place in scientific results is needed, a research gap that the current article aims to fill. Given the complexity of trust relationships, this influence might depend

on the research area and on social and cultural contexts in which public engagement is included.

In this article, we consider the case of public participation in urban studies. Citizen participation in geography mostly takes the form of what Sui, Elwood and Goodchild (2012) call geo-crowdsourcing. This kind of citizen science relies on the voluntary geographical information model first described by Goodchild (2007), where citizens play the role of 'sensors' reporting geographical data, mostly in a passive way. In contrast, our quasi-experimental citizen science project introduces a larger affective and cognitive investment from citizens who are actively involved in the identification and application of relevant criteria, to delineate urban functional areas. Our study thus aims to answer the following question: to what extent does active citizen participation in urban geography research influence the trust they place in scientific results ? We anticipate that this study will help to better grasp the role that citizen science may play in building a justified epistemic trust in science and scientists.

EMPIRICAL STUDY DESIGN

We conduct a two-stage quasi-experiment. In the first stage, the city and region of Łódź serve as the 'treatment region' where residents receive the 'treatment' of participation in a citizen science project aimed at delineating the boundaries of the metropolitan area. Although our study is not the first to use the participatory approach to the delineation of urban areas, we are the first to explicitly base our work on citizen science methods. Involving local residents in the delineation process is an appealing prospect as it allows us to tap into local knowledge – who better knows a city, town or village but people who live and work there every day. Thus, we expect citizens' practical knowledge of the terrain, transport and social connections and experience of services offered by local authorities, public institutions and businesses to be far superior to that of distant researchers.

In stage two, we introduce the city and region of Kraków as the 'control region' where residents did not participate in any delineation exercise. In both regions, we conduct an online survey in which we present results of the delineation research along with basic information about methods used. In Łódź, this is the citizen science project and the resulting map of the Łódź metropolitan area. In Kraków, this is a purely desk-based, academic-led delineation study utilising historical data from national statistical service and econometric regression methods, along with the resulting map. In the survey, we asked questions to ascertain levels of trust in the two sets of results. Subsequently, we compared the survey results from the two regions to determine whether involving citizens in the research process could have an impact on public trust in, and public perception of, research results.[2]

THE TALE OF TWO CITIES

We deployed our quasi-experiment in Kraków and Łódź (and their outskirts) which are, respectively, the second and third Polish cities in terms of population size. Our geographic unit of analysis is 'gmina' – the principal (lowest) unit of the administrative division of Poland. We ran a Facebook campaign aimed at recruiting participants living within 35 km radius from the centre of either core city. In each stage, participants were invited to contribute to the study over three weeks' periods: stage one in Łódź ran from 8 to 29 July 2020, and stage two ran both in Łódź and Kraków between 19 August and 9 September 2020. Table 1 compares key characteristics of the two cities, the study's geographic coverage area and the demographic profile of recruited study participants.

Table 1: Key characteristics of the study's geographic coverage area

	General population				Study participants		
	Łódź		Kraków		Łódź		Kraków
	City	Within 35 km	City	Within 35 km	Stage 1	Stage 2	Stage 2
Population (thousands) / participants	680	1,169	779	1,527	174	164	158
average age (years)	45.5	44.1	42.6	41.1	34.8	31.6	26.25
working age (%)	56.4	57.6	59.1	60	71.6	62	82
pre-working age (below 18, %)	15.1	16.1	17.2	18.7	13.6	23	15.3
retirement age (%)	28.5	26.3	23.7	21.3	14.8	15	2.7
female (%)	54.4	53.5	53.3	52	43.6	32.5	14.6
tertiary education[a] (%)	23.5	19.9	33.7	24.35	48.5	30.1	36.3
secondary education[a] (%)	39.9	37.3	38.4	34.6	40.4	47.2	44.6
Facebook: potential reach[b] (thousand users)		770		930			

Unless specified otherwise, the data is for 2019 and taken from Statistics Poland BDL (https://bdl.stat.gov.pl/BDL/start). [a] National Census 2011. [b] According to Facebook, the potential number of users that could be reached within 35 km of the city core, aged 16 and above.

At the city level, Kraków is larger in terms of population size and geographical area. When we look at the population characteristics, Kraków's inhabitants appear younger, with a slightly lower average age, a larger share of people of working age and significantly fewer of retirement age. A feature that sets the two cities apart is the educational structure: a third of Krakovians have a university degree, compared to less than a quarter in Łódź. Going beyond the city limits, our 'catchment areas', i.e. clusters of *gminas* located within 35 km of the core city centres, have populations of approximately 1.2 and 1.5 million inhabitants for Łódź and Kraków, respectively. The bottom row of Table 1 shows the potential reach of our Facebook campaign (that is, an estimated number of Facebook users based on Facebook's own calculations who lived within the catchment areas and were 16 or more years of age at the campaign's onset). Consistent with the larger number of inhabitants in Kraków and its vicinity, it is not surprising that its potential reach is 160,000 users larger than that of Łódź.

The last three columns of Table 1 present the basic demographic characteristics of our study's participants. Despite Łódź's smaller population size and Facebook's potential reach, our project attracted a moderately larger number of participants in Łódź than in Kraków. In the former, we had 174 and 164 participants at stages one and two, respectively, whereas stage two in Kraków attracted 158 participants. When we consider stage two only, the difference of six respondents between the two cities appears negligible and does not pose problems for the validity of the comparative analysis presented in the remainder of this article. Overall, it is clear that the study's participants do not form a statistically representative sample of the general population. The most striking differences are in age and gender. The study participants' average age is much lower than observed within the cities and catchment areas' populations. Females constitute over 50 per cent of all residents but they are significantly underrepresented, especially in stage two of our study.

Only one in three participants were female in Łódź. This number drops even further in Kraków where only one in seven were female. Other differences appear less striking although still significant. For example, more participants possessed a higher degree compared to the general populations. The difference is particularly conspicuous in stage one in Łódź where nearly half of the participants were university graduates, more than twice the share observed within the general population.

Citizen science projects do not usually require participants to form a group that is statistically representative of the general population. This has not been our intention either and should not undermine the results of our citizen science project in stage one of the study. However, the lack of statistical representativeness must be borne in mind when interpreting the results pertaining to the trust in research results in stage two and attempting to generalise them to a wider population.

RESULTS

In stage one, we consider empirical results from the citizen science project conducted around the city of Łódź. The main objectives of this exercise were to expose the local public to the research process and construct a map of the Łódź metropolitan area, based on citizen scientists' contributions. To ensure that answers to the delineation questions presented in Table A1 of the online appendix were reliable, and supported by a cognitive process, we provided participants with an explanation of the aims of the delineation study as well as a relevant definition of a metropolitan area.

Citizen scientists appear to agree that the practicalities of everyday life are the most important links forming the metropolitan area. An overwhelming majority of participants indicated access to public transportation and share of residents commuting to the core city as important criteria. What is worth noticing is that administrative decisions of central government are on the opposite end of the spectrum: 83 per cent of participants found them unimportant. Some respondents were keen to contribute additional factors. The most frequent ones were inhabitants' identifying themselves as Łodzians, the existence of strong emotional and historical ties to the core city, degree of urbanisation, enhanced cooperation and common ventures of *gminas*' authorities with the city of Łódź.

Following our analysis of citizen scientists' contributions, we drew a map of the Łódź metropolitan area based on citizens' responses to two key questions. First, whether in their opinion and experience the *gmina* in which they lived, worked, and attended school or university, belonged to the 'metropolitan area'. *Gminas* which were identified as such by at least 50 per cent of participants are selected as potential components of our citizen science map. Figure 1 shows that such *gminas* tend to cluster around the city of Łódź. Second, we asked them how far the metropolitan area spreads away from the centre of Łódź. The responses to this question were fairly consistent as citizen scientists indicated 30 km as the relevant radius (mean answer 30.48 km, median 30 km). Figure 2 displays the citizen science map of the metropolitan area (panel a.) and compares it to the delineation results obtained using econometric estimation methods (panel b.)[3].

Figure 1: Geographic extent of responses and share of respondents declaring that gminas belong to the metropolitan area

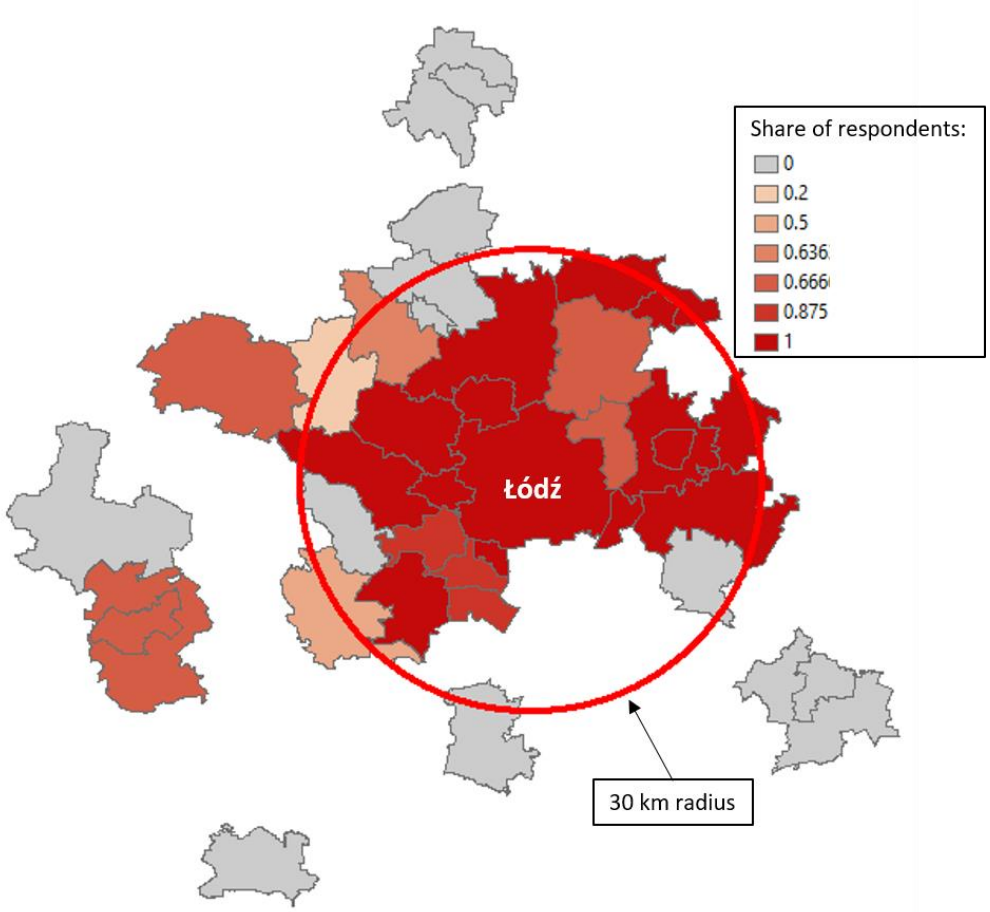
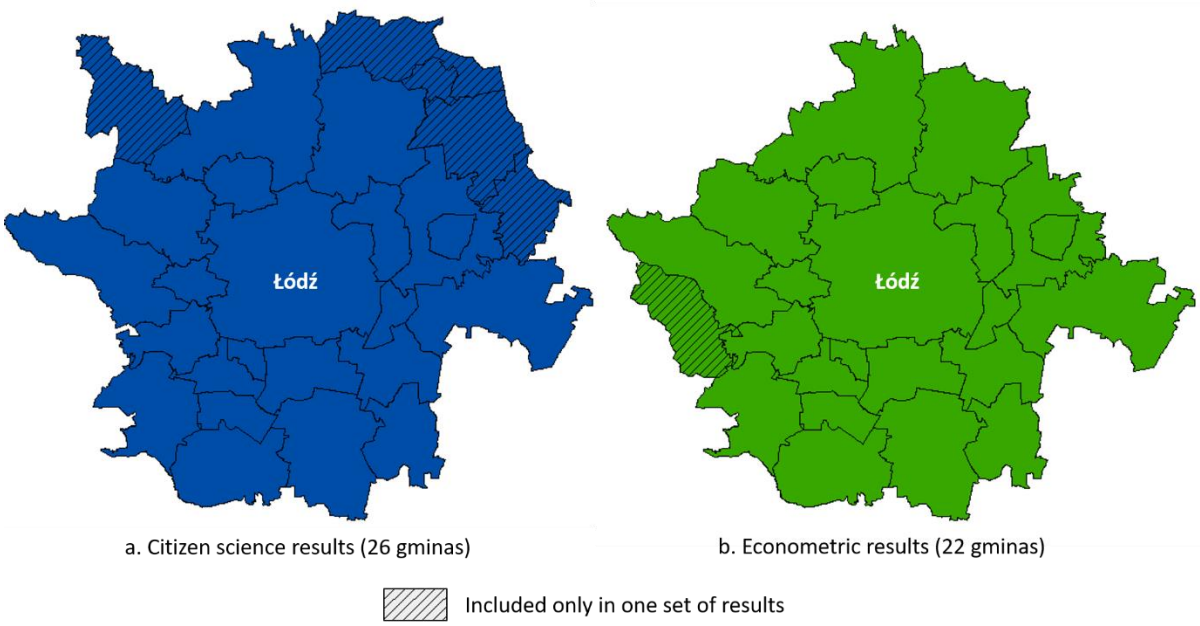


Figure 2: Maps of the Łódź metropolitan area used in stage two



The results of the delineation exercise presented in panel a. of Figure 2 are based on the contributions of a limited number of citizen scientists, and almost certainly could be improved by, for example, involving more participants or developing cognitively more advanced ways of engagement. Nonetheless, the primary aim of this study is not to develop a citizen science project which is epistemically robust, but to test whether involving laypersons in scientific research affects the trust that the public places in the results of scientific research. In this context, the presence of cognitive engagement from citizens is the most important determinant of the robustness of our study.

Stage two of our quasi-experiment aimed at comparing the levels of laypersons' trust in research results. To evaluate the influence of citizen participation on that trust, we developed an online survey (see Table A2 in the online appendix for the list of questions) which was promoted via Facebook among inhabitants of our treatment and control regions, and asked them to evaluate their trust in and perceived reliability of the presented research results in the form of a map of the relevant metropolitan area.

In both regions, the respondents were provided with basic information on the research process, with an emphasis on whether it involved the direct participation of citizen scientists or was purely academic research performed without laypersons' involvement. In the treatment region, Łódź, where the population was exposed to the citizen science project, respondents were shown the results of the delineation exercise conducted in stage one of the current study (panel a. of Figure 2). In the control region, Kraków, respondents were asked to evaluate the trustworthiness and reliability of the results of, previously mentioned, purely econometric and desk-based research delineating the metropolitan area of Kraków conducted by Gawrońska-Nowak, Lis and Zadorozhna (Forthcoming, see Figure B1 in the online appendix). Additionally in final questions, respondents in the Łódź region were also shown the map of the city's metropolitan area based on (Gawrońska-Nowak, Lis and Zadorozhna Forthcoming) as shown in panel b. of Figure 2 and provided with the background information. Consequently, they were asked to indicate which map, citizen-science or econometric based, provided a better representation of the actual Łódź metropolitan area and the results of which study were more trustworthy. The results are presented in Table 2. In addition, we test whether the differences in the levels of trust between Łódź and Kraków are statistically significant (Table C1 in the online appendix shows the relevant test results).

Our main observation is that people in the region of Łódź find citizen science results more reliable, and more trustworthy, than people in the region of Kraków, concerning econometric results (the differences are statistically significant at the 5 per cent and 1 per cent significance levels, respectively). When we delve deeper, we notice that the differences in trust levels come mostly from individuals with either secondary or primary education who are more likely to trust the citizen science results (the differences between Łódź and Kraków within these groups are statistically significant at the 5 per cent and 10 per cent significance levels). There is no statistically significant difference in trust between the two-city regions among people with tertiary education. When we consider the age groups, young and middle-aged people (aged 16 to 49) tend to trust the citizen science results more than the econometric results (statistical significance at 5 per cent). Unfortunately, women are rather underrepresented in the survey, especially when we look at Kraków. Therefore, we are unable to draw reliable conclusions on the relationship between gender characteristics and trust in our research results. Given that in both cities females represent 50 per cent of the population, understanding why they appear less likely to participate in research projects like ours is an attractive avenue for future research.

For brevity we do not describe in detail the remaining figures shown in Table 2, as they are self-explanatory. Overall, our survey results lead us to conclude that participation in citizen science projects has the potential to increase public trust in research outcomes. This is a positive finding as it illustrates that higher trust in research results should help to increase the overall trust that people place in science and scientists, which is crucial for

the sustained development of modern knowledge-based societies in which levels of mistrust are the focus of frequent media attention. There is still the question of whether citizen science increases trust only among individuals directly involved in the participatory research process (in our case, those who participated in phase one in Łódź), or whether knowledge that laypersons participated in the research can increase the level of trust among the general population. Our results suggest that the latter might be the case. Around 80 per cent of respondents in phase two in Łódź did not participate in phase one, and within that group the level of trust appears higher than among those who had taken part in phase one. Thus, we have no reason to believe that the beneficial impact of social science on trust is limited only to individuals directly involved in the research.

There are a few caveats to consider. First, the underrepresentation of women requires further investigations, and deserves special attention if the research community is to ensure the efficacy of citizen science projects in the future. Second, it remains an open question as to what could encourage people without tertiary (higher) education to be less sceptical or less neutral about citizen science projects, in order to transform them into supporters and promoters of that approach. Third, there is no guarantee that lay citizens living in the Polish metropolitan areas exhibit a universal pattern of behaviour that could be generalised to other places and societies. Neither can we cannot assume the opposite, and this requires further research.

Table 2: Trust in research results and their reliability

	Map is a good representation				Results can be trusted				Łódź only: citizen science vs. econometric study			
	Kraków		Łódź		Kraków		Łódź		Better map		More trustworthy	
	Yes	No	Yes	No	Yes	No	Yes	No	CSP	Econ.	CSP	Econ.
Overall sample	76%	24%	87%	13%	79%	21%	92%	8%	40%	35%	47%	30%
Participated in stage one[a]			84%	16%			84%	16%	42%	24%	61%	18%
In employment	76%	24%	90%	10%	79%	21%	88%	12%	36%	36%	49%	29%
In education	81%	19%	87%	13%	83%	17%	94%	6%	38%	36%	40%	34%
Retired	100%	0%	88%	13%	86%	14%	95%	5%	35%	27%	62%	19%
Education level												
Tertiary education	74%	26%	84%	16%	79%	21%	86%	14%	41%	24%	43%	22%
Secondary education	76%	24%	88%	12%	81%	19%	93%	7%	38%	40%	49%	34%
Below secondary	79%	21%	90%	10%	72%	28%	96%	4%	41%	38%	49%	32%
Female	95%	5%	89%	11%	96%	4%	89%	11%	40%	28%	47%	26%
Male	73%	27%	87%	13%	77%	23%	93%	7%	40%	37%	47%	32%
Age (years)												
16 - 29	77%	23%	86%	14%	81%	19%	92%	8%	36%	39%	40%	36%

	Map is a good representation				Results can be trusted				Łódź only: citizen science vs. econometric study			
	Kraków		Łódź		Kraków		Łódź		Better map		More trustworthy	
	Yes	No	Yes	No	Yes	No	Yes	No	CSP	Econ.	CSP	Econ.
30 - 49	67%	33%	100%	0%	73%	27%	100%	0%	50%	29%	57%	21%
50 - 64	67%	33%	93%	7%	71%	29%	86%	14%	35%	29%	65%	18%
65 and more	89%	11%	84%	16%	80%	20%	89%	11%	50%	23%	58%	19%

[a] 20.1% of respondents declared participation in stage one citizen science project.

DISCUSSION

This contribution pursued two distinct aims: developing new participatory methods to delineate metropolitan areas; and testing wether the use of this method influences public trust in scientific results and expertise. Before discussing our results, let us make some brief methodological remarks. First, we focused on trust placed in scientific results by citizens; this affective dimension cannot be directly related to the trustworthiness of the method used to produce our delineation results. In particular, the objective reliability of the method we propose should be assessed, notably by focusing more thorouthgly on the statistical significance of the population sample used to produce delimitation result. Second, we mostly tested here the trust placed in scientific results by citizen who were already engaged in our participatory research. It would be of interest to extend our work by also taking into account citizens who did not take part in the research. Concerning these two points, there is clearly room for futher research which would apply our delineation methods to other metropolitan areas.

In our fragmented and polarised societies, one of the dividing lines between technocracy and populism appears to surround what source(s) of knowledge and information are more trusted: expert knowledge or the 'true people voice', claimed to be represented by populists. The literature suggests that citizen science may provide an opportunity to break this polarisation by democratising science, exposing laypersons to the rigorous and methodological reasoning of scientists, informing them of research motivations, aims and drivers, and therefore increasing public trust in evidence-based knowledge and policies. Thus, by strengthening the fabric of knowledge-based societies, citizen science has the potential to help to mitigate the risks of populism. By showing that participation in our delineation study increases trust in the research results, especially among people without tertiary education, we demonstrate that citizen science is able to deliver on that promise. Our results suggest that participation in research is not merely beneficial because it increases epistemic trust in science, but also because it positively influences the most emotional drivers of trust.

Indeed, the advantage that citizen science has over the traditional top-down technocratic approach, both in research and policymaking, is that it is not afraid to treat laypersons as equal to experts, which triggers human passions and feelings such as confidence, trust and loyalty (Barbalet 1996). In our case study, citizen scientists consisting of the inhabitants of the Łódz region frequently identified themselves as 'Łodzians', even if formally they did not live within the city limits. They were showing and proving the existence of strong emotional and historical ties to the core city, and their involvement in the citizen science project was largely motivated by their emotional bond with the city. By contrast, in the philosophy of science literature, we find an increasing discontent over the sharp separation of emotions from science:

> Science can proceed only when emotions are excluded. This conventional view is widely held but false; indeed, practically meaningless. On the contrary: the issues must be: Which emotions? and how do they specifically relate to the activities at hand?' (Barbalet 2002: 132)

The clash between technocrats and populists is largely about human and societal emotions. Technocrats lose this clash essentially because of their inability to engage with human emotions.

Promoting laypersons' engagement in citizen science,which is characterised by cognitive, affective, social, behavioural and motivational dimensions, seems to be a real opportunity to break the populists' monopoly on the management of human and societal emotions. Nevertheless, effective implementation of citizen science projects requires some conditions to be met. Some of these are quite prosaic and practical (for example lack of funding or lack of training), but others seem to be more complex, ethical, methodological and theoretical concerns about whether citizen science can live up to standards of good scientific practice. After all, citizen science must also be 'good science' which conforms to

rigorous epistemological standards that high-quality research must meet. Even though some of these concerns are highly relevant, none of these concerns provides a compelling reason to challenge the overall need of the existence and development of citizen science in principle.

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ENDNOTES

[1]Survey data are consistent in showing that citizens express less trust in parliaments and political parties as well as politicians and experts (see the Edelman Trust Barometer, https://www.edelman.com/trustbarometer).

[2] For brevity, we do not present the detailed results and methods of the econometric analysis as they are not the focus of the current article. Detailed information on the econometric analysis can be found in Gawrońska-Nowak, Lis and Zadorozhna (2021) or obtained from the authors. The whole quasi-experiment procedure that we designed was inspired by a field experiment methodology developed by Banerjee, Duflo and Kremer in their Nobel Prize-winning works (see Duflo, Kremer and Robinson 2008; Banerjee and Duflo 2009).

[3] The econometric analysis was performed jointly for five Polish cities with population of 500,000 inhabitants or more using threshold regression and spatial threshold regression models with the number of commuters to the core city as the dependent variable. A detailed explanation of the analysis can be found in wrońska-Nowak, Lis and Zadorozhna (2021).

REFERENCES

Aitken, Mhairi, Sarah Cunningham-Burley and Claudia Pagliari (2016). 'Moving from Trust to Trustworthiness: Experiences of Public Engagement in the Scottish Health Informatics Programme'. *Science and Public Policy*, 43(5): 713-723. https://doi.org/10.1093/scipol/scv075

Allum, Nick, Patrick Sturgis, Dimitra Tabourazi and Ian Brunton-Smith (2008). 'Science Knowledge and Attitudes across Cultures: A Meta-Analysis'. *Public Understanding of Science*, 17(1): 35-54. https://doi.org/10.1177/0963662506070159

Anderson, Ashley A., Dietram A. Scheufele, Dominique Brossard and Elizabeth A. Corley (2012). 'The Role of Media and Deference to Scientific Authority in Cultivating Trust in Sources of Information about Emerging Technologies'. *International Journal of Public Opinion Research*, 24(2): 225-237. https://doi.org/10.1093/ijpor/edr032

Anderson, Elizabeth (2011). 'Democracy, Public Policy, and Lay Assessments of Scientific Testimony'. *Episteme*, 8(2): 144-164. https://doi.org/10.3366/epi.2011.0013

Banerjee, Abhijit V. and Esther Duflo (2009). 'The experimental approach to development economics'. *Annual Review of Economics*, 1: 151-178. https://doi.org/10.1146/annurev.economics.050708.143235

Barbalet, Jack (2002). 'Science and emotions'. *The Sociological Review*, 50(2): 132-150. https://doi.org/10.1111/j.1467-954X.2002.tb03595.x

Barbalet, Jack (1996). 'Social emotions: Confidence, trust, and loyalty'. *International Journal of Sociology and Social Policy*, 16(9/10): 75-96. https://doi.org/10.1108/eb013270

Biddle, Justin B. (2018). '"Antiscience Zealotry"? Values, Epistemic Risk, and the GMO Debate'. *Philosophy of Science*, 85(3): 360-379. https://doi.org/10.1086/697749

Bonney, Rick, Tina B. Phillips, Heidi L. Ballard, and Jody W. Enck (2016). "Can Citizen Science Enhance Public Understanding of Science?" *Public Understanding of Science*, 25(1): 2-16. https://doi.org/10.1177/0963662515607406

Carrier, Martin (2017). 'Facing the Credibility Crisis of Science: On the Ambivalent Role of Pluralism in Establishing Relevance and Reliability'. *Perspectives on Science*, 25(4): 439-464. https://doi.org/10.1162/POSC_a_00249

Cartwright, Nancy and Jeremy Hardie (2012). *Evidence-Based Policy: A Practical Guide to Doing It Better*. Oxford: Oxford University Press.

Committee on Science, Engineering and Public Policy (2009). *On Being a Scientist*. Washington, DC: National Academy Press.

Cooper, Caren B, and Bruce V. Lewenstein. (2016). 'Two Meanings of Citizen Science'. In Darlene Cavalier and Eric B. Kennedy (eds), *The Rightful Place of Science: Citizen science*. Temple, AZ: Consortium for Science, Policy & Outcomes: 51-62.

Critchley, Christine, Dianne Nicol and Margaret Otlowski (2015). 'The Impact of Commercialisation and Genetic Data Sharing Arrangements on Public Trust and the Intention to Participate in Biobank Research'. *Public Health Genomics*, 18(3): 160-172. https://doi.org/10.1159/000375441

Critchley, Christine R. (2008). 'Public Opinion and Trust in Scientists: The Role of the Research Context, and the Perceived Motivation of Stem Cell Researchers'. *Public Understanding of Science*, 17(3): 309-327. https://doi.org/10.1177/0963662506070162

Duflo, Esther, Michael Kremer and Jonathan Robinson (2008). 'How high are rates of return to fertilizer? Evidence from field experiments in Kenya'. *American Economic Review*, 98(2): 482-488. https://doi.org/10.1257/aer.98.2.482

Drummond, Caitlin and Baruch Fischhoff (2017). 'Individuals with Greater Science Literacy and Education Have More Polarized Beliefs on Controversial Science Topics'. *Proceedings of the National Academy of Sciences*, 114(36): 9587-9592. https://doi.org/10.1073/pnas.1704882114

Eitzel, Melissa, Jessica Cappadonna, Chris Santos-Lang, Ruth Duerr, Sarah Elizabeth West, Arika Virapongse, Christopher Kyba, Anne Bowser, Caren Cooper and Andrea Sforzi (2017). 'Citizen Science Terminology Matters: Exploring Key Terms'. *Citizen Science: Theory and Practice*, 2(1): 1-20. http://doi.org/10.5334/cstp.96

Eleta, Irene, Gemma Galdon Clavell, Valeria Righi and Mara Balestrini (2019). 'The Promise of Participation and Decision-Making Power in Citizen Science'. *Citizen Science: Theory and Practice*, 4(1): 8. http://doi.org/10.5334/cstp.171

European Commission (2016a). *Survey Report: Data Management in Citizen Science Projects*. Online: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC101077/lbna27920enn.pdf

European Commission (2016b). *Trust. European Research. Co-Creating Resilient Societies*. Online: https://www.net4society.eu/_media/Trust_Research%20Cocreating%20Resilient%20Societies.pdf

European Commission (2013). *In-Depth Report: Environmental Citizen Science* (Science for Environment Policy Issue 9). Online: https://ec.europa.eu/environment/integration/research/newsalert/pdf/IR9_en.pdf

European Commission (2010). *Science and Technology Report. Special Eurobarometer 340 / Wave 73.1-TNS Opinion and Social*. Online: https://ec.europa.eu/public_opinion/archives/ebs/ebs_340_en.pdf

European Commission (2007). *Taking European Knowledge Society Seriously*. Online: https://ec.europa.eu/research/science-society/document_library/pdf_06/european-knowledge-society_en.pdf

Gawrońska-Nowak, Bogna, Piotr Lis and Olha Zadorozhna (Forthcoming). 'Studium delimitacji obszarów funkcjonalnych miast za pomocą metod statystycznych'. In Bogna Gawrońska-Nowak (ed), *Jak definiować granice miejskich obszarów funkcjonalnych? Społeczne i ekonomiczne zyski i straty procesów urbanizacji w Polsce*. Warsaw: Wydawnictwo IRMiR.

Goodchild, Michael F. (2007). 'Citizens as Sensors: The World of Volunteered Geography'. *GeoJournal*, 69(4): 211-221. https://doi.org/10.1007/s10708-007-9111-y

Grasswick, Heidi E. (2010). 'Scientific and Lay Communities: Earning Epistemic Trust through Knowledge Sharing'. Synthese, 177(3): 387-409. https://doi.org/10.1007/s11229-010-9789-0

Grunwald, Armin (2003). 'Technology Assessment at the German Bundestag: "Expertising" Democracy for "Democratising" Expertise'. *Science and Public Policy*, 30(3): 193-198. https://doi.org/10.3152/147154303781780515

Hess, Charlotte, Elinor Ostrom and Gillian M. McCombs (2008). 'Understanding Knowledge as a Commons: From Theory to Practice'. College and Research Libraries, 69(1): 92-94.

Hornsey, Matthew J. and Kelly S. Fielding (2017). 'Attitude Roots and Jiu Jitsu Persuasion: Understanding and Overcoming the Motivated Rejection of Science'. *American Psychologist*, 72(5): 459-473. https://doi.org/10.1037/a0040437

Irzik, Gürol and Faik Kurtulmus (2019). 'What Is Epistemic Public Trust in Science?' *The British Journal for the Philosophy of Science*, 70(4): 1145-1166.

Lewandowsky, Stephan, John Cook and Elisabeth Lloyd (2018). 'The "Alice in Wonderland" Mechanics of the Rejection of (Climate) Science: Simulating Coherence by Conspiracism'. Synthese, 195(1): 175-196. https://doi.org/10.1007/s11229-016-1198-6

Lewandowsky, Stephan, Gilles E. Gignac and Klaus Oberauer (2013). 'The Role of Conspiracist Ideation and Worldviews in Predicting Rejection of Science'. *PloS One*, 8(10): e75637. https://doi.org/10.1371/journal.pone.0134773

Miller, Jon D. (2004). 'Public Understanding of, and Attitudes toward, Scientific Research: What We Know and What We Need to Know'. *Public Understanding of Science*, 13(3): 273-294. https://doi.org/10.1177/0963662504044908

Nadelson, Louis S. and Kimberly K. Hardy (2015). 'Trust in Science and Scientists and the Acceptance of Evolution'. *Evolution: Education and Outreach*, 8(1): 9. https://doi.org/10.1186/s12052-015-0037-4

National Academies of Sciences and Medicine (2015). Trust and Confidence at the Interfaces of the Life Sciences and Society: Does the Public Trust Science? A Workshop Summary. National Academies Press.

Office of Science and Technology Policy (2019). *Implementation of Federal Prize and Citizen Science Authority: Fiscal Years 2017-2018*. Online: https://www.whitehouse.gov/wp content/uploads/2019/06/Federal-Prize-and-Citizen-Science-Implementation-FY17-18-Report-June-2019.pdf

Pasek, Josh (2018a). "Don't Trust the Scientists! Rejecting the Scientific Consensus". Conspiracy Theories and the People Who Believe Them. New York: Oxford University Press.

Pasek, Josh (2018b). 'It's Not My Consensus: Motivated Reasoning and the Sources of Scientific Illiteracy'. *Public Understanding of Science*, 27(7): 787-806. https://doi.org/10.1177/0963662517733681

Resnik, David B. (2011). 'Scientific Research and the Public Trust'. *Science and Engineering Ethics*, 17(3): 399-409. https://doi.org/10.1007/s11948-010-9210-x

Ruiz Bravo, Norka (2007). 'The Challenge for NIH Ethics Policies: Preserving Public Trust and Biomedical Progress'. *Cleveland Clinic Journal of Medicine*, 74: S29. https://doi.org/10.3949/ccjm.74.suppl_2.s29

Rutjens, Bastiaan T., Steven J. Heine, Robbie M. Sutton and Frenk van Harreveld (2018). 'Attitudes towards Science'. Advances in Experimental Social Psychology, 57: 125-165.

Sarathchandra, Dilshani, Mark C. Navin, Mark A. Largent and Aaron M. McCright (2018). 'A Survey Instrument for Measuring Vaccine Acceptance'. *Preventive Medicine*, 109: 1-7. https://doi.org/10.1016/j.ypmed.2018.01.006

Sui, Daniel, Sarah Elwood and Michael Goodchild (2012). Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice. New York and London: Springer.

Van Brussel, Suzanne and Huib Huyse (2019). 'Citizen Science on Speed? Realising the Triple Objective of Scientific Rigour, Policy Influence and Deep Citizen Engagement in a Large-Scale Citizen Science Project on Ambient Air Quality in Antwerp'. *Journal of Environmental Planning and Management*, 62(3): 534-551. https://doi.org/10.1080/09640568.2018.1428183

Ziman, John (2003). 'Non-Instrumental Roles of Science'. Science and Engineering Ethics, 9(1): 17-27. https://doi.org/10.1007/s11948-003-0016-y